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(54) **Refrigerating system comprising a two-stage compression device.**

(57) The invention relates to a refrigerating system comprising a two-stage compression device, a condensor and at least two evaporators with throttling devices. The compression device is a two-stage free-piston compressor having two coaxially arranged cylinders in each of which a piston is movable, which pistons each influence a compression space with their head faces which are remote from each other and are rigidly connected to each other, the rigid connection carrying the moving part of a linear motor. Moreover, there is provided an electric control circuit by means of which both the stroke of the pistons and the centre position of the pistons can be controlled independently of each other by means of a voltage variation and a variation of the d.c. component respectively, so that the temperatures of the evaporators can be controlled independently of each other.

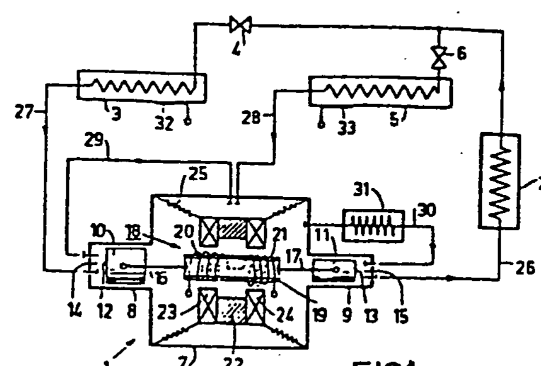

FIG.1

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"Refrigerating system comprising a two-stage compression device".

The invention relates to a refrigerating system comprising a two-stage compression device, a condensor and at least two evaporators with throttling devices.

Such a refrigerating system is disclosed in United States Patent Specification no. 2,559,367. The compression device described in this Patent Specification comprises a low-pressure compressor and a high-pressure compressor, whose pistons are each driven separately by a common electric motor. Such a system does not permit an independent temperature control of the evaporators.

It is the object of the invention to provide a refrigerating system comprising two evaporators whose temperatures can be controlled independently of each other, the system having a minimal power consumption.

To this end the refrigerating system according to the invention is characterized in that the compression device comprises a two-stage free-piston compressor with two coaxially arranged cylinders, in each of which a piston is movable, which pistons each influence a compression space with their head faces which are remote from each other, which pistons are rigidly connected to each other, the rigid connection carrying the moving part of a linear motor, and there is provided an electric control circuit by means of which both the stroke of the pistons and the centre position of the pistons can be controlled independently of each other by a voltage variation and a variation of the d.c. component respectively.

Since both the centre position and the stroke of the pistons of the compressor are controllable independently of each other an independent control of the two evaporator temperatures is possible using one continuously operating compressor. The continuous operation of the compressor means that both the two evaporators and the

common condensor are loaded continuously and hence to a minimal extent which reduces the temperature difference across these heat exchangers and thus the difference between the average evaporator and condensor temperatures (compared with an on/off compressor refrigerating system) resulting in an improved system efficiency.

An embodiment of the invention will now be described in more detail, by way of example, with reference to the drawing, in which

Figure 1 schematically shows the refrigerating system and

Figure 2 shows the electric control circuit.

The refrigerating system comprises a compression device 1, a condensor 2, a first evaporator 3 with a throttle value 4 and a second evaporator 5 with a throttle valve 6. The throttle valves can be adjustable restritions. The compression device comprises a compressor housing 7 with two coaxially arranged cylinders 8 and 9 in each of which a piston, 10 and 11 respectively, is movable. The head faces 12 and 13 of the respective pistons each influence a compression space 14 and 15 respectively. The pistons are rigidly connected to a moving soft-iron core 19 of a linear motor <u>18</u> by means of connecting rods 16 and 17 respectively. Around the soft-iron core two coil windings 20 and 21 are arranged. The stator of the linear motor comprises an iron ring 22 on both sides of which there are arranged radially oriented magnets with pole pieces 23 and 24 respectively for cooperation with the coil windings. The stator is suspended in the compressor housing 7 by means of stiff springs 25.

From the high-pressure compression space 15 a pressure line 26 leads to the condensor 2 and hence to the evaporators 3 and 5 which are arranged in parallel. From the evaporator 3 a suction line 27 leads to the low-pressure compression space 14. From the evaporator 5 a suction line 28 leads to the space inside the hermatically sealed compressor housing 7. From the low-pressure compression space 14 a pressure line 29 also leads to the

space inside the compressor housing. Via a line 30, in which an intermediate cooler 31 is arranged, the space inside the compressor housing communicates with the high-pressure compression space 15.

The refrigerant vapour from the evaporator 3, which has the lowest temperature, is fed to the first stage, i.e. the low-pressure compression space 14. The vapour leaves this stage with a temperature of approximately 60°C and after having passed the intermediate cooler 31 with a temperature of approximately 40°C it goes to the inlet of the second stage, i.e. the high-pressure compression space 15. The advantage of this low inlet temperature is that the compressor efficiency increases. The vapour from the evaporator 5 goes after being heated by motor heat losses inside the space of the compressor housing 7 and subsequently cooled by the intermediate cooler 31 to the second stage.

Especially in a system in which two compartments have to be maintained at different temperatures, such as a refrigerator-freezer combination, this system reduces the power consumption. During continuous operation the capacities of the evaporator can be varied independently of each other by varying the stroke and adjusting the centre position of the pistons. Increasing the stroke results in an increase of the capacity of both evaporators. Depending on the required refrigeration the refrigerating capacity of one of the evaporators may be further increased, whilst that of the other is reduced, resulting in an independent control of each evaporator. Increasing the stroke is effected by a voltage variation (for example through phase-shift control of an alternating voltage), and the centre position is varied by the addition of a d.c. component. The voltage is an a.c. motor drive voltage which normally has a d.c. component. This is schematically represented in Figure 2. In the comparators 34, 35 the signals of two temperature-sensitive elements 32 and 33, which detect the temperatures of the evaporators 3 and 5 respectively are compared with the reference signals of

the adjustable reference sources 38, 39, respectively. The resultant signals (with hysteresis in case of thermostats) are transferred to trigger-circuits with thyristor control (ortriac) 36, which supplies an a.c., which may have been phase-shifted, to the motor coil 20-21. Each of the two triggering circuits 40, 41 influences the a.c. by phase cutting either the positive or negative part, thus causing a phase shift and amplitude change. This results in different powers delivered to each of the two pistons. Moreover, the two resultant signals are added via a d.c. amplifier 37 and the resultant thereof is applied to the coil as a d.c. component for controlling the centre position.

CLAIMS

1. A refrigerating system comprising a two-stage compression device, a condensor and at least two evaporators for the throttling devices, characterized in that the compression device comprises a two-stage free-piston compressor with two coaxially arranged cylinders, in each of which a respective piston is movable, which pistons each influence a compression space with their head faces which are remote from each other, which pistons are rigidly connected to each other, the rigid connection carrying the moving part of a linear motor, and there is provided an electric control circuit by means of which both the stroke of the pistons and the centre position of the pistons can be controlled independently of each other by a voltage variation and a variation of the d.c. component respectively.

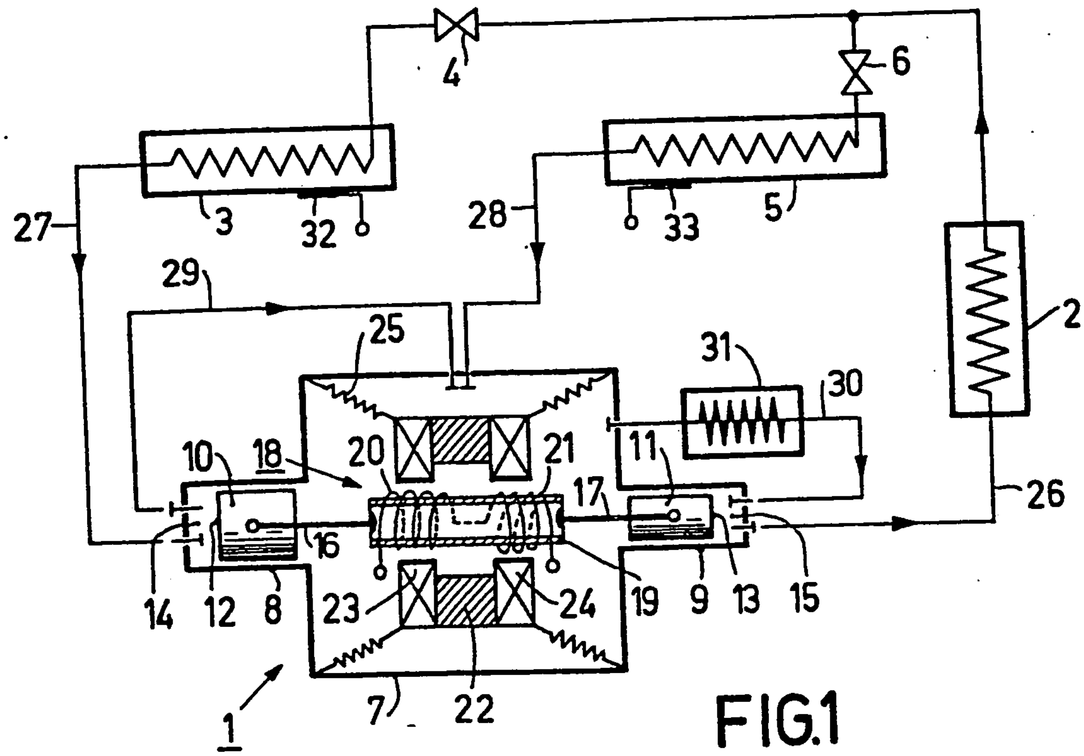
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FIG.1

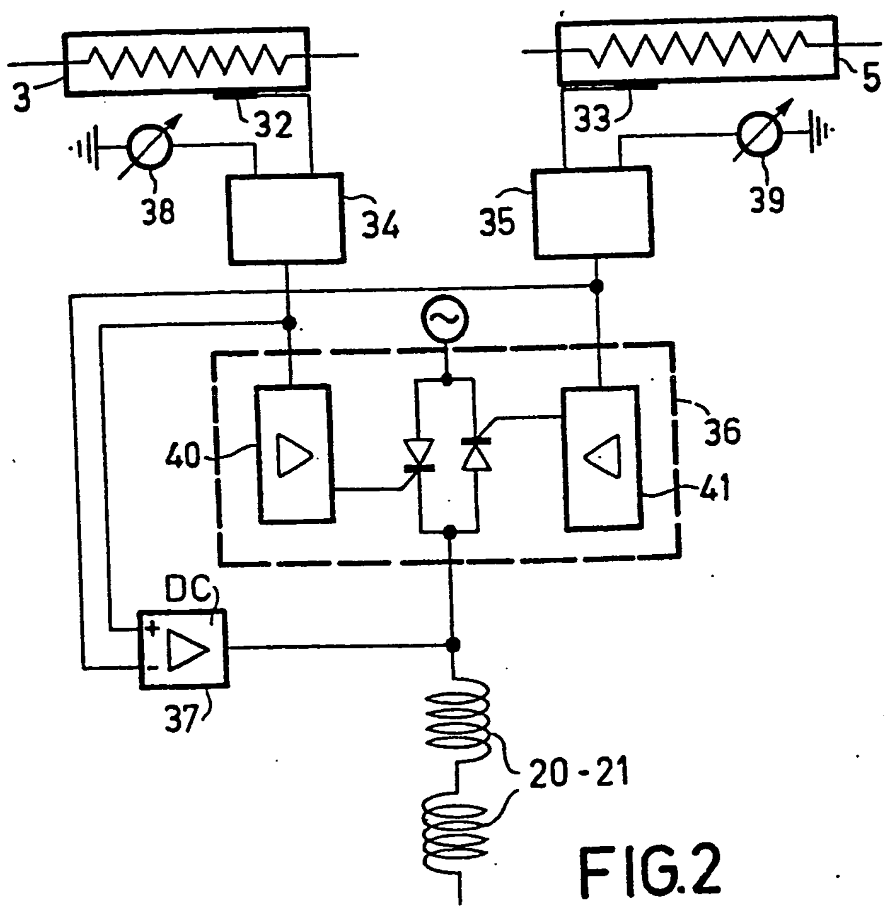
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FIG.2

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